(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 959 862 B2

(12) NEW EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the opposition decision:
19.01.2005 Bulletin 2005/03

(45) Mention of the grant of the patent:
28.11.2001 Bulletin 2001/48

(21) Application number: **96928000.7**

(22) Date of filing: **16.07.1996**

(51) Int Cl.7: **A61G 10/00**, A62B 7/00, A62B 9/00, A62B 18/00, A62B 31/00, A61M 15/00, A61M 16/00

(86) International application number:
PCT/US1996/011792

(87) International publication number:
WO 1997/003631 (06.02.1997 Gazette 1997/07)

(54) HYPOXIC ROOM SYSTEM AND EQUIPMENT FOR HYPOXIC TRAINING AND THERAPY

HYPOXISCHES RAUMSYSTEM UND EINRICHTUNG FÜR HYPOXISCHES TRAINING UND THERAPIE

SYSTEME DE CHAMBRE HYPOXIQUE ET EQUIPEMENT DESTINE A L'ENTRAINEMENT ET A LA THERAPIE HYPOXIQUE

(84) Designated Contracting States:
AT CH DE FR GB IT LI

(30) Priority: **21.07.1995 US 505621**

(43) Date of publication of application:
01.12.1999 Bulletin 1999/48

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Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates to a system for providing oxygen-depleted air to a user for hypoxic training ortherapy whereby a low-oxygen mountain air of different altitudes is simulated, and more particularly, to a system which regulates oxygen content and the humidity of the oxygen-depleted air being delivered for non-contact inhaling by a user.

[0002] Hypoxic training activates the immune system and protective forces of the organism, and is used for medical, health and fitness purposes. Hypoxic training is a drug-free alternative for treatment and prevention of cardiopulmonary, gastrointestinal, gynecological, skin and ocular diseases, as well as various types of allergy, neurological disturbances, and other diseases. Hypoxic Training is also successfully used for increasing strength, endurance, vitality and resistance to various diseases of healthy people and athletes.

[0003] European Patent EP 0472 799 A1 shows one type of the apparatus for Hypoxic Training on the market. The apparatus employs a powerful compressor to force air through hollow polyfiber membranes in order to provide an oxygen-depleted gas mixture to the user.

[0004] This apparatus has a number of disadvantages including excessive weight and noise level and higher than atmospheric pressure of the delivered gas mixture as well. But the main disadvantage of this and other currently available machines is the necessity of sterilization or disposal of the contaminated elements of the respiratory system and the possibility of contamination of the entire system.

[0005] WO 95/13044 discloses a system for regulating the atmosphere in a substantially closes sports/exercise space or an animal shelter, especially in terms of partial oxygen pressure. In that known system, a desired normbaric atmosphere is created in a substantially closed space by means of mixing nitrogen with air - a method, widely used by sport and medical scientists since 1970 for simulating altitude hypoxia. This system requires a constant supply of liquid gases and expensive gas storage, mixing and monitoring equipment. Moreover, if such monitoring or regulating equipment fails, people may die in a nitrogen enriched atmosphere. A possible use of nitrogen and oxygen generators is suggested, but not described, forthe same known method of mixing nitrogen with ambient air.

[0006] US 5 101 819 discloses a system for inducing hypoxic symptoms in persons in hypobaric chambers using a selectively permeable separator system or a nitrogen generator system.

[0007] The underlying problem is to provide a system according to the preamble of claim 1 which is free of the above mentioned disadvantages and can be effectively used for hypoxic training and therapy by providing a reduced oxygen gas mixture to the internal space of the breathing chamber.

[0008] According to the invention, this problem is solved by the features of claim 1. The dependent claims show advantageous and useful embodiments of the invention.

[0009] The several embodiments presented here employ varying combinations of equipment for supplying an oxygen-depleted gas mixture for hypoxic training or therapy which requires an air composition preferably with 7 % to 15 % of oxygen and 93 % to 85 % of nitrogen.

[0010] Each embodiment presented here may be incorporated into an air-conditioning system of any room, building or structure using the systems ventilating ducts and equipment for delivery hypoxic gas mixture.

[0011] In the following, the invention is explained in detail by means of the drawings.

Fig. 1 : shows a simplified view of the preferred embodiment of the invention.

Fig. 2 : is schematic view of the preferred embodiment wherein an oxygen-enriched gas mixture is extracted from the system.

Fig. 3 : shows a schematic of an alternate embodiment of the invention which the outside installation of a hypoxicator.

Fig. 4 : shows a schematic view of another alternate embodiment of the invention.

Fig. 5 : shows a schematic of a membrane-type hypoxicator.

Fig. 6 : shows a schematic of a molecular sieve-type hypoxicator.

Fig. 7 : shows a schematic view of an alternate molecular sieve-type hypoxicator.

The inventive system consists of two main blocks: a hypoxicator (oxygen-extraction device for supply oxygen-depleted air with a control unit) and a hypoxic training room comprising a breathing chamber which communicate with each other.

[0012] Figure 1 shows a simplified design of a preferred embodiment 10, and Figure 2 shows a schematic working principle of the same embodiment. A collapsible hypoxic training room 11 comprises soft or hard walls made preferably from a clear glass or polymer material supported on a metal or plastic framework 19 and equipped with a door 12, a ceiling 13 and an optional floor platform. There are many types of similar rooms marketed currently as "clean room" or "inhalation room" and manufactured by Liberty Industries, Simplex Inc., Clean Room Products Inc., Clestra Cleanroon, Inc. and many other companies. Most of them are suitable for the present invention and need just a few changes, such as getting ventilating and installation openings.

[0013] A hypoxicator 15 employs almost the same

working principle as is well-known in medical field membrane-type or molecular sieve-type oxygen concentrators which separate ambient air into oxygen-rich and nitrogen-rich fractions. The main difference between the hypoxicator and an oxygen concentrator is that with an oxygen concentrator, the oxygen-rich gas mixture is used and nitrogen concentrate is released into the atmosphere, and with the hypoxicator, the nitrogen-rich gas mixture is used and the oxygen concentrate is disposed of. The hypoxicator presented in this invention is also several times more productive and does not need a number of elements necessary in oxygen concentrator devices. In this invention a custom-made hypoxicator with membrane or molecular-sieve air separation unit is used being schematically shown in figures 5 and 6 and described later in this document.

[0014] The hypoxicator 15 installed inside the hypoxic room 11 draws internal room air through a disposable dust and bacterial filter of inlet 16 and separates it into oxygen concentrate disposed through outlet 17 and nitrogen concentrate being discharged inside room 11 through outlet 18.

[0015] The constant gas mixture withdrawal from room 11 through outlet 17 causes the same quantities of fresh air to be drawn in through the ventilating openings 14, keeping normal atmospheric pressure inside room 11. The air-flow capacity of openings 14 must be larger than the maximal flow of the oxygen concentrate able to be produced by the hypoxicator 15. It will allow an even atmospheric pressure inside the hypoxic room 11.

[0016] The system has a significant advantage -- it allows also the simulation of hypobaric conditions existing in reality on different altitudes which is important for hypoxic training and therapy. For this purpose, ventilating openings 14 may be equipped with the hypobaric valves allowing to create a necessary pressure difference inside the room 11. In this case it is advisable to reduce the number of openings 14 to one or two of a larger size. These valves (or valve) should be combined with a room pressure monitor and controlled by a computerized control unit which will change the air pressure inside the room 11 in accordance to the oxygen content level allowing perfectly-simulated mauntain air conditions at different altitudes. Suitable low-pressure valves with an extremely sensitive room pressure monitor (model RPM-1) and other necessary accessories are available from MODUS Instruments, Inc.

[0017] The performance of the hypoxicator 15 must be enough to lower the oxygen content of the air inside the room 11 to desired level in a desired amount of time. Preferred are those able to produce at least 15 cubic feet (450 liters) per minute of nitrogen concentrate with minimum 90% purity which should be enough for one individual training room. For larger rooms more efficient hypoxicators should be used or a sluice chamber installed at the entrance in order to save energy by frequent door openings. There is no need to make the door, wall and ceiling joins of the hypoxic room 11 absolutely airtight and it may be used without a floor platform as well.

[0018] The hypoxic room should be equipped with an oxygen-content sensor and an oxygen-depletion alarm (both not shown). Suitable are those manufactured by Micro Switch(a Honeywell Div.), Sensormedics Corp., Servomex, Matheson Gas Products, Enmet Corp. and others.

[0019] The oxygen-content sensor constantly measures the oxygen content in the room and transmits the data to a computerized control unit (not shown) which controls the performance of the hypoxicator 15 to achieve and maintain desired air parameters in accordance to training or therapy protocol.

[0020] Preferred oxygen content parameters for hypoxic training ortherapy lie in the range from 7% to 13% for controlled medical use and 11%-15% for public use for fitness purposes.

[0021] It is also necessary for medical purposes to employ a pulse oximeter which measures SaO2 - blood saturation with oxygen, preferably finger type. Pulse oximeters manufactured by Nellcor Inc., Edentec, Ohmeda, Puritan-Bennet Corp. and Simed Corp. are suitable.

[0022] The oximeter mounted on a finger of a user transmits constantly the pulse rate and SaO2 - data to the computerized control unit which chooses the hypoxic parameters most suitable for a user.

[0023] A humidity and temperature control unit (not shown) may be installed in the system in orderto control humidity and temperature inside the room 11.

[0024] When the room 11 is in use and the door 12 is closed, the hypoxicator 15 draws the internal room air through the intake 16 returning only the oxygen-depleted gas mixture through the outlet 18 and discharging the oxygen concentrate through the outlet 17 outside the room 11. Fresh air is drawn through the ventilating openings 14 equalizing atmospheric pressure inside the room 11 and being mixed with the incoming through the outlet 18 oxygen-depleted air. The oxygen content level of the air inside the room 11 drops to preset proportions which are maintained by the computerized control unit during the session time in accordanceto training ortherapy protocol and users conditions.

[0025] Another big advantage of the invention presented here is a gradual lowering of the oxygen content of the air inside the hypoxic room during the session which allows a better adaptation to hypoxic condition and eliminates hypoxic shock. A computerized control unit constantly informs a user about the simulated altitude he reaches during a session.

[0026] Carbon dioxide produced by a user during a training or therapy session settles because of its higher density and is removed through the low-positioned intake 16 from the room 11. Because of its permeability, which is higher than oxygen and nitrogen, carbon dioxide penetrates faster the oxygen-separating membrane of the hypoxicacor 15 and is fully discharged into the

atmosphere through the outlet 17. In case of a molecular sieve-type hypoxicator, carbon dioxide remains with the oxygen concentrate and is removed completely as well.

[0027] When the desired oxygen content level is established inside the room 11 and the computerized control unit significantly reduces performance of the hypoxicator 15 the carbon dioxide constantly produced by a user will be always removed first and completely from the room 11.

[0028] Excessive moisture will be also removed from the room 11 because of the faster permeability of water vapor through the oxygen separating membrane, but the humidity of the air inside room 11 will be constantly reinstated because of the existance of ventilating openings and kinetic properties of water vapor.

[0029] Figure 3 shows a schematic design of an alternate embodiment 30 which differs from the preferred embodiment only through the outside installation of the hypoxicator 35. The air inside the hypoxic training room 31 is drawn through the intake 36 inside hypoxicator 35 wherein it is separated into oxygen concentrate being disposed through the output 37 and oxygen-depleted gas mixture being returned through the outlet 38 back into room 31, etc. All other parts and devices are the same as in the preferred embodiment.

[0030] Figure 4 shows a further alternate embodiment 40 wherein the oxygen-depleted air is pumped inside the room 41. The hypoxicator 45 installed preferably outside the room 41 draws outside air through the dust filter of the intake 46 and disposes oxygen-rich gas mixture through the outlet 47 blowing the oxygen-depleted air into the room 41 through the outlet 48.

[0031] In this embodiment ventilating openings 44 should be installed preferably in the lower portion of the room walls allowing carbon dioxide to be blown out first. The air flow capacity of the ventilating openings 44 must be greater than the volume of the incoming gas mixture by maximal performance of the hypoxicator 45, because it is necessary to keep normal atmospheric pressure inside the hypoxic training room 41.

[0032] This alternate embodiment requires a humidifier in order to reinstate the humidity of the incoming dry gas mixture to desired proportions. It is necessary because water vapor is faster than other gases in penetrating an oxygen-separating membrane which makes oxygen-depleted retentate too dry for comfortable use. In case of a molecular sieve separator water vapor is removed with the oxygen concentrate.

[0033] The preferred type of humidifier is a disc spray dispenser widely used in air conditioning systems and which can employ the power of the incoming air stream to produce micro-sized water droplets which evaporate instantly. Any other humidifiers available on the market for home or office use are suitable for the invention presented here and may be installed separately inside or outside a hypoxic room. All other parts and equipment are similar to the preferred embodiment. Hyperbaric conditions may be easily established, if necessary, employing hyperbaric valves at the ventilating openings 44 controlled by a room pressure monitor and computerized control unit similar to the preferred embodiment.

[0034] Figure 5 shows a schematic design and a working principle of the membrane type hypoxicator 50. A compressor 51 draws an ambient air and supplies compressed air through an conduit 52 into a membrane separation unit 53 wherein it is separated into oxygen rich permeate and oxygen depleted retentate. The permeate is drawn by a vacuum pump 54 being disposed through the conduit 56 and the retentate is discharged through the conduit 55 inside the hypoxic room (not shown).

[0035] The system can also work without the vacuum pump 54 being installed here for increasing the efficiency of the separation unit 53. Otherwise, a fan or a blower may be used instead of compressor 51 in which case an efficient vacuum pump 54 is required to achieve the highest air separation grade across the membranes of the separation unit 53.

[0036] Most suitable for invention presented here are Thomas WOBL double piston compressors (series 1207 and 2807) and Thomas WOBL piston or rotary vacuum pumps (series TF16, TF25 and 2750) manufactured by Thomas Industries, Inc.

[0037] The membrane separation unit 53 is of known construction and may consist of a set of parallel connected membrane cells or a single cell which employ either flat or capillary membranes. The inlet of the separation unit 53 receives compressed airfrom conduit 52, and separates the air across the membrane and delivers the oxygen-depleted retentate gas through the outlet to conduit 55. The separation results from a pressure difference created by a compressor 51 and/or vacuum pump 54 expelling the oxygen-rich permeate gas mixture as a result of this compressor and vacuum pump arrangement, the retentate gas mixture is delivered further inside a hypoxic room. Similar membrane separation units, usually with hollow-fiber-polymer membranes, are used currently in the medical oxygen-enriching devices.

[0038] The best material for the membranes is selected from the group consisting of poly(dimethylsiloxane) also referred to as PDMS or its copolymer, or poly[1-(trimethylsilyl)-1-propyne] also referred to as PMSP, available from the Sanyo Chemical Co., the Matsushita Electric Company or the General. Electric Co. Also suitable for use in forming the membranes of the present invention are silicon rubber, natural rubber, carbon, polybutadiene, polystyrene, ethylcellullose, butyl rubber, Teflon-FEP, polyvinylacetate, poly(2,6-dimethylphenylene oxide) or poly(methylpentene-1). Suitable for use in forming the membranes are porous polyethylene or polypropylene available from Terumo, Bentley, Johnson & Johnson, Bard, Baxter Travenol, 3M, Shiley or Cope. Other possible materials will be apparent to those skilled in the art, who will be able to substitute equivalent materials for those enunciated here without departing from

the invention.

[0039] In the preferred embodiment, membrane cells are made with a porous, tubular-shaped support structure having a permeable flat sheet membrane layer on the retentate side of the support structure, the membrane layer being preferably from highly permeable organic, synthetic, ceramic, glass, metal, composite, mineral or biologic material, or combinations thereof in symmetric, asymmetric or composite shape, porous or non-porous. Capillary or hollow-fiber membranes may also be used effectively instead of flat membranes.

[0040] Due to their kinetic properties, water vapor, carbon dioxide and oxygen penetrate faster through any kind of membranes than nitrogen, which permits a choice of the most permeable membrane underthe lowest possible air pressure in order to increase an efficiency of the membrane separation unit 53.

[0041] A humidifier may be connected to hypoxicator 50, if necessary, or installed separately in hypoxic room.

[0042] Figure 6 shows a schematic design and a working principle of the molecular-sieve type hypoxicator 60 which are almost similar to medical oxygen concentrators being commercialized since mid-1970s and operating on the original Skarstrom cycle.

[0043] A compressor 61 draws an ambient air and pressurizes it preferably up to 3 to 10 bar pressure. Compressed air is delivered through the outlet 62, switching valves 63 and air flow paths 64 to sieve bed 65 or sieve bed 66 alternately. The molecular sieve material of sieve beds 65, 66 adsorbes nitrogen from the compressed air, allowing oxygen and other gases to pass through to disposal conduits 67 and 68.

[0044] The two sieve beds 65 and 66 are pressurized alternately in a cyclic manner whereby air flow paths 64 are switched by solenoid switching valves 63. The sieve beds are made preferably from steel used for high-pressure gas containers. As soon as sieve material in sieve bed 65 becomes saturated with nitrogen a pressurizing valve 69 opens depressurizing bed 65, allowing nitrogen to flow through conduit 71 to mixing outlet 73 connected to hypoxic room (not shown here). Some of the oxygen produced at this time by bed 66 is used to purge bed 65 (connections from conduit 68 to bed 65 and from 67 to 66 are not shown here in order to simplify the scheme). At that time sieve bed 66 becomes saturated with the nitrogen and a pressurizing valve 70 opens, allowing depressurization of the bed 66 and the nitrogen being flown through a conduit 72 to the mixing outlet 73. The complete cycle is then repeated.

[0045] Oxygen disposal conduits 67 and 68 having pressure regulator valves 74 and 75 may join each other, allowing single-tube oxygen transmission to a wasting point.

[0046] The performance of compressor 61 is controlled by a manual or computerized control unit constantly receiving data from an oxygen content sensor, oximeter and other electronic sensors inside a hypoxic room.

[0047] The particulary preferred materials for adsorbing nitrogen are molecular-sieve zeolites or crystalline aluminosilicates of alkali earth elements, both synthetic and natural, and Molecular-Sieve Carbon, type CMSO2, available from Calgon Corp., Bergbau-Forschung GmbH in Germany and Takeda Chemical Company in Japan. Organic zeolites, pillared interlayer clays (PILCS) and other suitable molecular sieve materials may also be used.

[0048] The productivity of the hypoxicator in this embodiment should preferably be in a range from 30 to 50 liters per minute of oxygen with 80% to 90% purity which will allow establishing of 12%O2 hypoxic conditions in a 5 cubic meters (185 cubic feet) training room in approximately 10 to 20 minutes.

[0049] The most suitable compressor for this embodiment is the Thomas WOBL piston compressor. A humidifier may be connected to hypoxicator 60, if necessary, or installed separately in hypoxic room.

[0050] Figure 7 shows a scheme of a most efficient embodiment of hypoxicator 80 employing preferably Molecular Sieve Carbon type CMSN2 in a pressure-swing adsorption system which allows to produce nitrogen with up to 99.9% purity and absolutely free from carbon dioxide.

[0051] Compressor 81 supplies air pressurized preferably up to 3 to 10 bar through the outlet 82, switching valve 83 and connectors 84 to molecular sieve beds 85 and 86. Each sieve bed is alternately pressurized in a cyclic manner and supplies nitrogen until it becomes saturated with oxygen. Bed 85 is pressurized by closing a pressurizing valve 89 and adsorption process begins. Oxygen and carbon dioxide are adsorbed by the adsorbent and nitrogen flows through the pressure regulator valve 94 and conduit 87 to mixing outlet 93 connected to hypoxic room (not shown). When adsorbent in the bed 85 becomes saturated with oxygen, solenoid valve 83 switches the flow path of the compressed air to bed 86 which is pressurized by closing pressurizing valve 90.

[0052] At the same time, the bed 85 is depressurized by opening valve 89, allowing oxygen to escape from the adsorbent and to be disposed through the conduit 91 and outlet 96. At that time, the adsorbent in the sieve bed 86 becomes saturated with oxygen and valve 83 switches air flow path to bed 85 which is pressurized by closing valve 89. The complete cycle is then repeated.

[0053] One, three or four-bed adsorbing units may be made using the same principle, if necessary. CMSN2 is also available from Bergbau-Forschung GmbH and Takeda Chemical Company. Zeolites made of organic materials are also suitable. Under normal operating conditions, the molecular sieve is completely regenerative and will last indefinitely.

[0054] The Thomas piston compressors are most suitable for this embodiment. A humidifier may be connected to hypoxicator 80 or installed separately in hypoxic room. All necessary switches, valves, pressure regalators, manometers, pressure display-controllers and transmitters, filters, fittings and tubing are available from

Modus Instruments, Inc., Victor Equipment Company and AirSep Corporation.

[0055] The invented system could be applied to any closed room or structure, such as a patient room in a hospital, residential rooms, fitness club rooms, office and conference rooms, schools and child care facilities, theatres, cinemas, restaurants and even a room inside a motor vehicle or other means of transportation. Two basic conditions must be met to build a system are sufficient ventilation of the room allowing instant reinstating of the atmospheric pressure inside the room and a safe disposal of oxygen. For instance, a hypoxicator may be installed as shown in figures 1-4 inside or outside a fitness room having a sufficient ventilation through the door or window.

[0056] The hypoxic room system may be easily integrated into any air conditioning system of any building or structure using existing ventilation ducts and equipment for delivery hypoxic gas mixture to any floor or room in the building. This will improve peoples state of health, increase their productivity and lower medical expenses. A hypoxicator may be incorporated into any separate room air conditioner.

[0057] The shown on Fig. 4 installation scheme of hypoxicator makes the system most suitable and safe for use in a passenger car or other motor vehicles with a closed passenger space. Since most of Americans waste hours of their active life every week inside a car some of this time could be used to their advantage -- for hypoxic training.

[0058] A small, preferably 12V/DC - powered hypoxicator with membrane or molecular sieve type separation principles described earlier may be installed inside a car interior or behind a dashboard. There is also enough space inside or under passenger seats. A hypoxicators delivery system may be also integrated in a ventilating system. Two conditions must be met in this embodiment in orderto create an invented hypoxic room system: an outside air must be drawn for separation and an oxygen concentrate must be discharged outside a car. There are many openings in a car body sufficient to play a role of ventilating openings 44 and constantly equalizing air pressure in a car interior with the outside atmospheric pressure and, if necessary more openings could be made, preferably at doorjambs.

[0059] The lowest oxygen content of the supplied gas mixture should be preferably 13% - 15% by maximal hypoxicators performance which is absolutely safe and unnoticable by a user and even may be used for fighting sleepiness and increasing attentiveness and vitality. In case of a membrane-type hypoxicator it is simple to preset the performance of the separation unit for a steady supply of the air with 13-15% of oxygen.

[0060] In case of a molecular sieve adsorption separator, the produced nitrogen should be mixed with the fresh air in proportion 1 : 2.5 which makes the air with exactly 15% of oxygen. The mixing must be safe and automatically which may be achieved by transmitting nitrogen through "Y"-shaped mixing adapter with a larger fresh air intake opening, allowing 2.5 times more ambient air than nitrogen to be automatically sucked into the system for mixing. This and a computerized control unit with the oxygen-depletion alarm will insure the safety of the system for hypoxic training inside a car.

[0061] The installation scheme shown on Fig. 2 is also suitable for closed-type motor vehicles. In this case, car ventilation ducts and other car body openings play the role of ventilation openings 14. An oxygen concentrate may be discharged to outside through any specially made opening for outlet 17. The best place for incorporating outlet 17 is an outside mirror supporting structure because it communicates with the a car interior through the mirror adjustment mechanism wherein a connection tubing should be installed inside the mirror supporting structure ending with a specially made opening outside and with the connector at inner panel of the door for hypoxicators outlet 17.

[0062] An inhalation mask with hypoxic air supply tubing retractable from a dashboard or other interior part may be also installed for individual hypoxic training inside a motor vehicle. In this case a mask should be preferably handheld, without any straps, which is safer. This application is most beneficially for a long-distance truck drivers or train operators. A motorist, feeling drowsy, could take a 3-5 minute session of hypoxic inhalation which will significally increase his cardiopulmonary activity, attention and vitality.

[0063] Car manufacturers could easily integrate this invention in a ventilating system of a vehicle as an additional luxury feature. The presented here invention may be marketed as an anti-sleep mode device for operators of any means of transportation. The system can switch on automatically if a user wears on a finger or another body part a pulse oximeter connected to a computerized or fuzzy logic control unit. When a pulse rate of a user drops to the lowest for this individual level a system will be switched on automatically and hypoxic conditions will be established for a time, necessary to increase user activity to desired level. A blood saturation with oxygen is also under constant control.

[0064] A big advantage of the invented system forthis application is that it does not disturb a user and does not cause a "panic effect" which is genetically preset in humans if a part of the oxygen in the air is replaced by carbon dioxide. The system may be successfully used for hypoxic training of mammals as well.

Claims

1. A system for hypoxic training and therapy for providing a reduced-oxygen atmosphere to a user within an external atmospheric environment of air at an external ambient air pressure, said system comprising:

an oxygen-extraction device having an inlet (16, 36, 46) intaking an intake gas mixture and first and second outlets (17, 37, 47; 18, 38, 48), said first outlet (17, 37, 47) transmitting a first gas mixture derived from said intake gas mixture and having a higher oxygen content than the intake gas mixture and said second outlet (18, 38, 48) transmitting a second gas mixture derived from said intake gas mixture and having an oxygen content lower than the oxygen content of the intake gas mixture but of at least 7 %;

a breathing chamber having an internal space therein containing air, and including an entry communicating with said internal space and through which the user can enter said internal space;

said second outlet (18, 38, 48) communicating with said internal space and transmitting said second mixture to said internal space so that said second mixture mixes with the air in the internal space and

said first outlet (17, 37, 47) transmitting said first mixture to said external atmospheric environment;

said breathing chamber having ventilating openings (14, 34, 44) permitting the communication of air in at least one direction between the external atmospheric environment and the internal space to an extent that, in combination with the oxygen-extraction device the air in the internal space is maintained at a pressure generally equalized with the ambient air pressure of the external atmospheric environment and at a substantially constant concentration of oxygen of at least 7 % but substantially lower than the external ambient oxygen concentration.

2. The system according to claim 1, wherein said inlet (16, 36) of said oxygen-extraction device communicates with said internal space and intakes the intake gas mixture from the air in said internal space.

3. The system according to claim 1, wherein said inlet (46) of said oxygen-extraction device intakes the intake gas mixture from the air of said external atmospheric environment.

4. The system according to claim 3, wherein the air flow capacity of said ventilating openings (14, 34, 44) is greater than the volume of said second gas mixture delivered by said oxygen-extraction device.

5. The system according to anyone of the preceding claims, wherein the air in the internal space has an oxygen concentration of 7 to 15%.

6. The system according to anyone of the preceding claims, wherein exercise equipment for training of said user is provided in said internal space of said breathing chamber.

7. A system according to anyone of the preceding claims, wherein said breathing chamber comprises a door (12) and wall structure defining a closed space into which the user can enter through the door (12).

8. The system according to anyone of the preceding claims, wherein the oxygen-extraction device is located outside the breathing chamber, said second outlet (38, 48) being connected with said chamber so that the reduced-oxygen gas mixture is emitted into said closed space inside the chamber and mixes with the air therein causing the air in the closed space to have a lower oxygen concentration than the air outside the chamber.

9. The system according to anyone of the preceding claims, wherein said oxygen-extraction device comprises a separation unit to which the intake gas mixture from the inlet (16, 36, 46) is transmitted, said separation unit separating the intake gas mixture into a reduced oxygen gas mixture with an oxygen concentration lower than said intake mixture and an enhanced oxygen gas mixture with an oxygen concentration higher than said intake mixture, said separation unit having a reduced oxygen mixture conduit (55, 71, 72, 87, 88) through which the reduced oxygen gas mixture is transmitted and an enriched oxygen mixture conduit (56, 67, 68, 91, 92) through which the enriched oxygen gas mixture is transmitted;

said second outlet (18, 38, 48) being operatively associated with said reduced oxygen mixture conduit (55,71,72,87,88) and receiving said reduced oxygen gas mixture therefrom, said first outlet (17, 37, 47) being operatively associated with said enriched oxygen mixture conduit (56, 67, 68, 91, 92) and receiving said enriched oxygen gas mixture therefrom and releasing said enriched oxygen mixture to said outside environment.

10. The system according to claim 9, wherein said separation unit comprises a housing defining a space therein, said housing having a separating membrane supported therein and dividing the space to define a retentate space and a permeate space, said separation unit further comprising a pump pumping said gas mixture across said membrane and causing said gas mixture to be separated thereby into oxygen enriched permeate in said permeate space which is transmitted to said first outlet (17, 37, 47) and oxygen depleted retentate in said retentate space which is transmitted to said second outlet (18, 38, 48) and released inside said chamber.

11. The system according to claim 9, wherein said oxygen-extraction device comprises a pump applying said intake gas mixture to a pressure swing adsorption device having molecular sieve material which adsorbs nitrogen from the intake gas mixture being compressed by said pump, leaving unabsorbed the enriched oxygen mixture which is transmitted to the enriched oxygen conduit (67, 68) and discharged to the outside environment, said adsorption device on depressurization releasing a nitrogen concentrate gas which is transmitted as said reduced oxygen mixture to said reduced oxygen conduit (71, 72) and released into said chamber.

12. The system according to claim 9, wherein said oxygen-extraction device comprises a pump applying said intake gas mixture to a pressure swing adsorption device having molecular sieve material which adsorbs oxygen from the intake gas mixture being compressed by said pump, leaving unabsorbed the reduced oxygen mixture which is transmitted to said reduced oxygen conduit (87, 88) and released into said chamber, said adsorption device on depressurization releasing an oxygen concentrated gas which is transmitted as said enriched oxygen mixture to the enriched oxygen conduit (91, 92) and discharged to the outside environment.

13. The system according to anyone of the preceding claims, wherein said ventilating openings (14, 34) in said chamber are located in a upper portion of the chamber.

14. The system according to anyone of claims 1 to 12, wherein said ventilating openings (44) in said chamber are located in a lower portion of the chamber.

15. The system according to anyone of the preceding claims, wherein said chamber is a part of a vehicle and said user is an operator of said vehicle, said system selectively supplying said low-oxygen environment so as to maintain the alertness of said operator.

16. The system according to anyone of the preceding claims, comprising a control unit controlling the operation of said oxygen-extraction device and an oxygen content sensor monitoring the oxygen content of said air inside said internal space communicating with said control unitto maintain the oxygen content of the air in the internal space at a desired level.

17. The system according to anyone of the preceding claims, wherein said system has a humidity and temperature control unit regulating humidity and temperature of the air inside said internal space.

18. The system according to claim 16, wherein said system further comprises a pulse oximeter monitoring the user's pulse rate and blood saturation with oxygen. said oximeter transmitting data to said control unit, and said control unit regulating the oxygen content of the air inside said internal space responsive to said oximeter data.

19. The system according to anyone of the preceding claims, wherein said system comprises exercise equipment inside said internal space for hypoxic training of humans or other mammals.

20. The system according to anyone of the preceding claims, wherein said chamber having said internal space is part of a building, said oxygen-extraction device being incorporated into an air-conditioning system of said building and using ventilation ducts of the building for delivery of reduced oxygen air to said internal space.

Patentansprüche

1. System für hypoxisches Training und hypoxische Therapie zum Bereitstellen einer sauerstoffreduzierten Atmosphäre für einen Benutzer innerhalb einer externen atmosphärischen Luftumgebung mit externem Umgebungsluftdruck, wobei das System aufweist:

   eine Sauerstoffextraktionsvorrichtung mit einem Einlass (16, 36, 46), über den eine Zufuhrgasmischung zugeführt wird, und einem ersten und zweiten Auslass (17, 37, 47; 18, 38, 48), wobei der erste Auslass (17, 37, 47) eine erste Gasmischung überträgt, die von der Zufuhrgasmischung abgeleitet wird und einen höheren Sauerstoffgehalt als die Zufuhrgasmischung aufweist, und wobei der zweite Auslass (18, 38, 48) eine zweite Gasmischung überträgt, die von der Zufuhrgasmischung abgeleitet wird und einen Sauerstoffgehalt aufweist, der niedriger als der Sauerstoffgehalt der Zufuhrgasmischung, jedoch mindestens 7% ist;
   eine Atmungskammer, die einen Luft enthaltenden Innenraum und einen Eingang aufweist, der mit dem Innenraum in Verbindung steht und durch den der Benutzer den Innenraum betreten kann;

   wobei der zweite Auslass (18, 38, 48) mit dem Innenraum in Verbindung steht und die zweite Mischung zum Innenraum leitet, so dass sich die zweite Mischung mit der Luft im Innenraum vermischt, und

   wobei der erste Auslass (17, 37, 47) die erste Mischung zur äußeren Atmosphärenumgebung leitet;

wobei die Atmungskammer Lüftungsöffnungen (14, 34, 44) aufweist, welche den Austausch von Luft in wenigstens einer Richtung zwischen der externen Atmosphärenumgebung und dem Innenraum in einem Ausmaß ermöglicht, dass, in Kombination mit der Sauerstoffextraktionsvorrichtung, die Luft im Innenraum bei einem Druck gehalten wird, der im wesentlichen gleich dem Umgebungsluftdruck der externen Atmosphärenumgebung ist, sowie bei einer im Wesentlichen konstanten Sauerstoffkonzentration, die wenigstens 7 % beträgt, jedoch wesentlich niedriger ist als die externe umgebende Sauerstoffkonzentration.

2. System nach Anspruch 1, bei dem der Einlass (16, 36) der Sauerstoffextraktionsvorrichtung mit dem Innenraum in Verbindung steht und die Zufuhrgasmischung aus der Luft im Innenraum zuführt.

3. System nach Anspruch 1, bei dem der Einlass (46) der Sauerstoffextraktionsvorrichtung die Zufuhrgasmischung aus der Luft der externen Atmosphärenumgebung zuführt.

4. System nach Anspruch 3, bei dem die Luftstromkapazität der Lüftungsöffnungen (14, 34, 44) größer ist als das Volumen der von der Sauerstoffextraktionsvorrichtung gelieferten zweiten Gasmischung.

5. System nach einem der vorhergehenden Ansprüche, bei dem die Luft im Innenraum eine Sauerstoffkonzentration von 7 bis 15 % hat.

6. System nach einem der vorhergehenden Ansprüche, bei dem im Innenraum der Atmungskammer eine Trainingsvorrichtung zum Trainieren des Benutzers vorgesehen ist.

7. System nach einem der vorhergehenden Ansprüche, bei dem die Atmungskammer eine Tür (12) und eine Wandstruktur aufweist, welche einen geschlossenen Raum begrenzen, in den der Benutzer durch die Tür (12) hindurch eintreten kann.

8. System nach einem der vorhergehenden Ansprüche, bei dem die Sauerstoffextraktionsvorrichtung außerhalb der Atmungskammer angeordnet ist, wobei der zweite Auslass (38, 48) mit der Kammer derart verbunden ist, dass die sauerstoffreduzierte Gasmischung in den geschlossenen Raum innerhalb der Kammer ausgegeben wird und sich mit der darin befindlichen Luft vermischt, wodurch bewirkt wird, dass die Luft im geschlossenen Raum eine niedrigere Sauerstoffkonzentration als die Luft außerhalb der Kammer hat.

9. System nach einem der vorhergehenden Ansprüche, bei dem die Sauerstoffextraktionsvorrichtung eine Trenneinheit aufweist, zu der die Zufuhrgasmischung vom Einlass (16, 36, 46) übertragen wird, wobei die Trenneinheit die Zufuhrgasmischung in eine sauerstoffreduzierte Gasmischung mit einer niedrigeren Sauerstoffkonzentration als die Zufuhrmischung und eine sauerstoffangereicherte Gasmischung mit einer höheren Sauerstoffkonzentration als die Zufuhrmischung trennt, wobei die Trenneinheit eine Leitung (55, 71, 72, 87, 88) für die sauerstoffreduzierte Mischung aufweist, durch die die sauerstoffreduzierte Gasmischung gefördert wird, und eine Leitung (56, 67, 68, 91, 92) für die sauerstoffangereicherte Mischung, durch die die sauerstoffangereicherte Gasmischung gefördert wird;

wobei der zweite Auslass (18, 38, 48) wirkungsmäßig mit der Leitung für die sauerstoffreduzierte Mischung (55, 71, 72, 87, 88) verbunden ist und von dieser die sauerstoffreduzierte Gasmischung empfängt, wobei der erste Auslass (17, 37, 47) wirkungsmäßig mit der Leitung für die sauerstoffangereicherte Mischung (56, 67, 68, 91, 92) verbunden ist und von dieser die sauerstoffangereicherte Gasmischung empfängt sowie die sauerstoffangereicherte Mischung in die äußere Umgebung freigibt.

10. System nach Anspruch 9, bei dem die Trenneinheit ein Gehäuse aufweist, das einen Raum begrenzt, wobei das Gehäuse eine Trennmembran aufweist, die darin gehaltert ist und den Raum teilt, um einen Retentatraum und einen Permeatraum zu bilden, wobei die Trenneinheit ferner eine Pumpe aufweist, welche die Gasmischung durch die Membran hindurch pumpt und bewirkt, dass hierdurch die Gasmischung im Permeatraum in ein sauerstoffangereichertes Permeat, das zum ersten Auslass (17, 37, 47) geleitet wird, und ein sauerstoffreduziertes Retentat im Retentatraum getrennt wird, das zum zweiten Auslass (18, 38, 48) geleitet und innerhalb der Kammer ausgegeben wird.

11. System nach Anspruch 9, bei dem die Sauerstoffextraktionsvorrichtung eine Pumpe aufweist, welche die Zufuhrgasmischung an eine Druckschwankungsadsorptionsvorrichtung heranbringt, welche ein molekulares Siebmaterial aufweist, das Stickstoff aus der Zufuhrgasmischung adsorbiert, die durch die Pumpe komprimiert wird, wobei es die sauerstoffangereicherte Mischung unabsorbiert lässt, die zur sauerstoffangereicherten Leitung (67, 68) geleitet und in die äußere Umgebung ausgegeben wird, wobei die Adsorptionsvorrichtung auf eine Druckverringerung hin ein Stickstoffkonzentratgas freigibt, das als sauerstoffreduzierte Mischung zur sauerstoffreduzierten Leitung (71, 72) gefördert und in die Kammer ausgegeben wird.

12. System nach Anspruch 9, bei dem die Sauerstoff-

extraktionsvorrichtung eine Pumpe aufweist, welche die Zufuhrgasmischung zu einer Druckschwankungsadsorptionsvorrichtung führt, die ein molekulares Siebmaterial aufweist, welches Sauerstoff aus der Zufuhrgasmischung adsorbiert, die durch die Pumpe komprimiert ist, wobei es die sauerstoffreduzierte Mischung unabsorbiert lässt, die zur sauerstoffreduzierten Leitung (87, 88) geleitet und in die Kammer ausgegeben wird, wobei die Adsorptionsvorrichtung auf eine Druckverringerung hin ein Sauerstoffkonzentratgas freigibt, das als sauerstoffangereicherte Mischung zur sauerstoffangereicherten Leitung (91, 92) geleitet und in die äußere Umgebung ausgegeben wird.

13. System nach einem der vorhergehenden Ansprüche, bei dem die Lüftungsöffnungen (14, 34) in der Kammer in einem oberen Bereich der Kammer angeordnet sind.

14. System nach einem der Ansprüche 1 bis 12, bei dem die Lüftungsöffnungen (44) in der Kammer in einem unteren Bereich der Kammer angeordnet sind.

15. System nach einem der vorhergehenden Ansprüche, bei dem die Kammer ein Teil eines Fahrzeugs und der Benutzer ein Fahrer des Fahrzeugs ist, wobei das System die sauerstoffarme Umgebung wahlweise zur Verfügung stellt, um die Wachsamkeit des Fahrers aufrechtzuerhalten.

16. System nach einem der vorhergehenden Ansprüche, mit einer Steuereinheit, welche den Betrieb der Sauerstoffextraktionsvorrichtung steuert, und einem Sauerstoffgehaltsensor, der den Sauerstoffgehalt der Luft innerhalb des Innenraums überwacht und mit der Steuereinheit verbunden ist, um den Sauerstoffgehalt der Luft im Innenraum auf einem gewünschten Niveau zu halten.

17. System nach einem der vorhergehenden Ansprüche, bei dem das System eine Feuchtigkeits- und Temperatursteuereinrichtung aufweist, welche die Feuchtigkeit und die Temperatur der Luft innerhalb des Innenraums reguliert.

18. System nach Anspruch 16, bei dem das System ferner einen Pulsoximeter aufweist, welcher die Pulsrate des Benutzers und die Blutsättigung mit Sauerstoff überwacht, wobei der Oximeter Daten zur Steuereinheit überträgt und wobei die Steuereinheit den Sauerstoffgehalt der Luft innerhalb des Innenraums in Abhängigkeit der Oximeterdaten reguliert.

19. System nach einem der vorhergehenden Ansprüche, bei dem das System innerhalb des Innenraums eine Trainingseinrichtung zum hypoxischen Training von Menschen oder anderen Säugetieren aufweist.

20. System nach einem der vorhergehenden Ansprüche, bei dem die den Innenraum aufweisende Kammer Teil eines Gebäudes ist, wobei die Sauerstoffextraktionsvorrichtung in das Klimaanlagensystem des Gebäudes eingebaut ist und Lüftungsöffnungen des Gebäudes zum Befördern der sauerstoffreduzierten Luft in den Innenraum verwendet.

Revendications

1. Système pour un entraînement et une thérapie hypoxique pour fournir une atmosphère à oxygène réduit à un utilisateur à l'intérieur d'un environnement atmosphérique externe d'air à pression ambiante externe, ledit système comprenant:

- un dispositif d'extraction d'oxygène ayant une entrée (16, 36, 46) pour l'entrée d'un mélange de gaz admis, et une première et une deuxième sortie (17, 37, 47; 18, 38, 48), ladite première sortie (17, 37, 47) transmettant un premier mélange de gaz dérivé dudit mélange de gaz admis et ayant une teneur en oxygène plus élevée que le mélange de gaz admis, et ladite deuxième sortie (18, 38, 48) transmettant un deuxième mélange de gaz dérivé depuis ledit mélange de gaz admis et ayant une teneur en oxygène inférieure à la teneur en oxygène du mélange de gaz admis, mais au moins égale à 7 % ;
- une chambre de respiration ayant un espace interne à l'intérieur contenant de l'air, et incluant une entrée en communication avec ledit espace interne et via laquelle l'utilisateur peut pénétrer dans ledit espace interne ;
- ladite deuxième sortie (18, 38, 48) communiquant avec ledit espace interne transmettant ledit deuxième mélange audit espace interne, de sorte que ledit deuxième mélange se mélange avec l'air dans l'espace interne ;
- ladite première sortie (17, 37, 47) transmettant ledit premier mélange audit environnement atmosphérique externe ; et
- ladite chambre de respiration ayant des ouvertures de ventilation (14, 34, 44) permettant la communication d'air dans au moins une direction entre l'environnement atmosphérique externe et l'espace interne, dans une mesure telle que, en combinaison avec le dispositif d'extraction d'oxygène, l'air dans l'espace interne est maintenu à une pression généralement égalisée avec la pression de l'air ambiant de l'environnement atmosphérique externe, et à une concentration d'oxygène sensiblement constante d'au moins 7 %, mais sensiblement infé-

rieure à la concentration en oxygène ambiante externe.

2. Système selon la revendication 1, dans lequel ladite entrée (16, 36) dudit dispositif d'extraction d'oxygène communique avec ledit espace interne, et admet le mélange de gaz admis depuis l'air dans ledit espace interne.

3. Système selon la revendication 1, dans lequel ladite entrée (46) dudit dispositif d'extraction d'oxygène admet le mélange de gaz admis depuis l'air dudit environnement atmosphérique externe.

4. Système selon la revendication 3, dans lequel la capacité de débit d'air desdites ouvertures de ventilation (14, 34, 44) est supérieure au volume dudit deuxième mélange de gaz fourni par ledit dispositif d'extraction d'oxygène.

5. Système selon l'une quelconque des revendications précédentes, dans lequel l'air dans l'espace interne a une concentration d'oxygène de 7 à 15 %.

6. Système selon l'une quelconque des revendications précédentes, dans lequel un équipement d'exercice pour l'entraînement dudit utilisateur est prévu dans ledit espace interne de ladite chambre de respiration.

7. Système selon l'une quelconque des revendications précédentes, dans lequel ladite chambre de respiration comprend une porte (12) et une structure de paroi définissant un espace fermé dans lequel l'utilisateur peut pénétrer à travers la porte (12).

8. Système selon l'une quelconque des revendications précédentes, dans lequel le dispositif d'extraction d'oxygène est situé à l'extérieur de la chambre de respiration, ladite deuxième sortie (38, 48) étant connectée avec ladite chambre de sorte que le mélange de gaz à oxygène réduit est émis dans ledit espace fermé à l'intérieur de la chambre et ce mélange avec l'air dans celle-ci, amenant l'air dans l'espace fermé à présenter une concentration en oxygène plus faible que l'air à l'extérieur de la chambre.

9. Système selon l'une quelconque des revendications précédentes, dans lequel ledit dispositif d'extraction d'oxygène comprend une unité de séparation à laquelle le mélange de gaz admis est transmis depuis l'entrée (16, 36, 46), ladite unité de séparation séparant le mélange de gaz admis en un mélange de gaz à oxygène réduit avec une concentration en oxygène plus faible que ledit mélange admis, et un mélange de gaz à concentration renforcée en oxygène, avec une concentration en oxygène supérieure audit mélange admis, ladite unité de séparation ayant un conduit de mélange à oxygène réduit (55, 71, 72, 87, 88) à travers lequel le mélange de gaz à oxygène réduit est transmis, et un conduit de mélange à oxygène enrichi (56, 67, 68, 91, 92) à travers lequel est transmis le mélange de gaz à oxygène enrichi ; - ladite deuxième sortie (18, 38, 48) étant fonctionnellement associée audit conduit de mélange à oxygène réduit (55, 71, 72, 87, 88) et recevant de celui-ci ledit mélange de gaz à oxygène réduit, ladite première sortie (17, 37, 47) étant fonctionnellement associée avec ledit conduit de mélange à oxygène enrichi (56, 67, 68, 91, 92) et recevant de celui-ci ledit mélange de gaz enrichi en oxygène, et libérant ledit mélange enrichi en oxygène vers ledit environnement extérieur.

10. Système selon la revendication 9, dans lequel ladite unité de séparation comprend un boîtier définissant un espace en lui-même, ledit boîtier ayant une membrane de séparation supportée à l'intérieur et divisant l'espace pour définir un espace à rétentat et un espace à perméat, ladite unité de séparation comprenant en outre une pompe qui pompe ledit mélange de gaz de part et d'autre de ladite membrane et qui provoque la séparation dudit mélange de gaz par celle-ci en un perméat enrichi en oxygène dans ledit espace à perméat, qui est transmis à ladite première sortie (17, 37, 47) et en un rétentat appauvri en oxygène dans ledit espace à rétentat, qui est transmis à ladite deuxième sortie (18,38, 48) et libéré à l'intérieur de ladite chambre.

11. Système selon la revendication 9, dans lequel ledit dispositif d'extraction d'oxygène comprend une pompe qui applique ledit mélange de gaz admis à un dispositif d'adsorption à oscillations de pression ayant un matériau de tamisage moléculaire qui absorbe l'azote depuis le mélange de gaz admis qui est comprimé par ladite pompe, en laissant non absorbé le mélange enrichi en oxygène qui est transmis au conduit enrichi en oxygène (67, 68) et déchargé vers l'environnement extérieur, ledit dispositif d'adsorption libérant, lors de la dépressurisation, un gaz azoté concentré qui est transmis comme étant ledit mélange à oxygène réduit vers ledit conduit à oxygène réduit (71, 72) et libéré dans ladite chambre.

12. Système selon la revendication 9, dans lequel ledit dispositif d'extraction d'oxygène comprend une pompe qui applique ledit mélange de gaz admis à un dispositif d'absorption à oscillations de pression ayant un matériau de tamisage moléculaire qui absorbe l'oxygène depuis le mélange de gaz admis en étant comprimé par ladite pompe, laissant non absorbé le mélange à oxygène réduit qui est transmis audit conduit d'oxygène réduit (87, 88) et libéré

dans ladite chambre, ledit dispositif d'adsorption libérant, lors de la dépressurisation, un gaz concentré en oxygène qui est transmis comme étant ledit mélange enrichi en oxygène vers le conduit d'oxygène enrichi (91, 92) et déchargé vers l'environnement extérieur.

13. Système selon l'une quelconque des revendications précédentes, dans lequel lesdites ouvertes de ventilation (14, 34) dans ladite chambre sont situées dans une partie supérieure de la chambre.

14. Système selon l'une quelconque des revendications 1 à 12, dans lequel lesdites ouvertures de ventilation (44) dans ladite chambre sont situées dans une partie inférieure de la chambre.

15. Système selon l'une quelconque des revendications précédentes, dans lequel ladite chambre est une partie d'un véhicule, et ledit utilisateur est un opérateur dudit véhicule, ledit système fournissant de manière sélective ledit environnement à oxygène réduit de façon à maintenir le degré d'éveil dudit opérateur.

16. Système selon l'une quelconque des revendications précédentes, comprenant une unité de commande qui commande le fonctionnement dudit dispositif d'extraction d'oxygène, et un capteur de teneur en oxygène qui surveille teneur en oxygène de l'air à l'intérieur dudit espace interne en communication avec ladite unité de commande pour maintenir la teneur en oxygène de l'air dans l'espace interne à un niveau désiré.

17. Système selon l'une quelconque des revendications précédentes, dans lequel ledit système comprend une unité de commande d'humidité et de température, qui régule l'humidité et la température de l'air à l'intérieur dudit espace interne.

18. Système selon la revendication 16, dans lequel ledit système comprend encore un oxymètre à impulsions surveillant la cadence du pouls et la saturation du sang de l'utilisateur en oxygène, ledit oxymètre transmettant des données à ladite utilisé de commande, et ladite unité de commande régulant la teneur en oxygène de l'air à l'intérieur dudit espace interne en réponse auxdites données provenant de l'oxymètre.

19. Système selon l'une quelconque des revendications précédentes, dans lequel ledit système comprend un équipement d'exercice à l'intérieur dudit espace interne pour l'entraînement hypoxique des êtres humains, ou d'autres mammifères.

20. Système selon l'une quelconque des revendications précédentes, dans lequel ladite chambre ayant ledit espace fait partie d'un bâtiment, ledit dispositif d'extraction d'oxygène étant incorporé dans un système de conditionnement d'air dudit bâtiment et utilisant des conduits du bâtiment pour la fourniture d'air à oxygène réduit vers ledit espace interne.

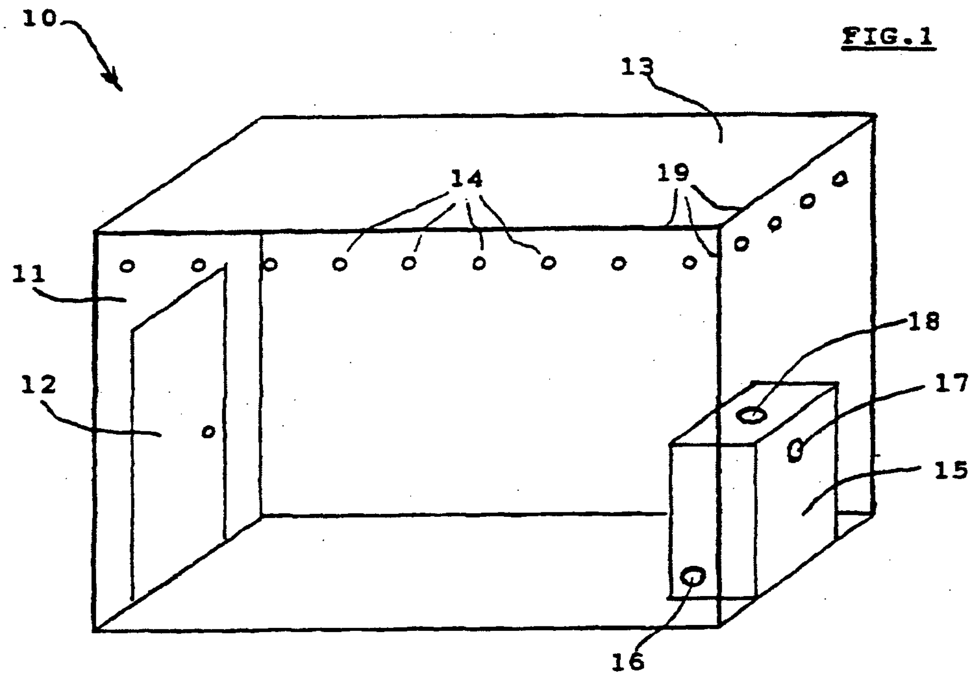

FIG.1

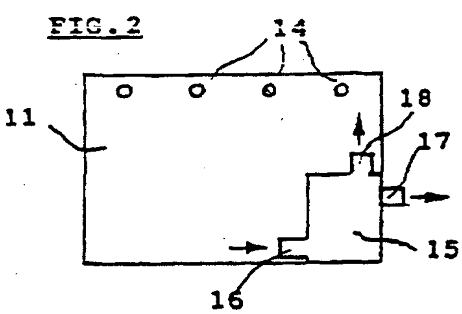

FIG.2

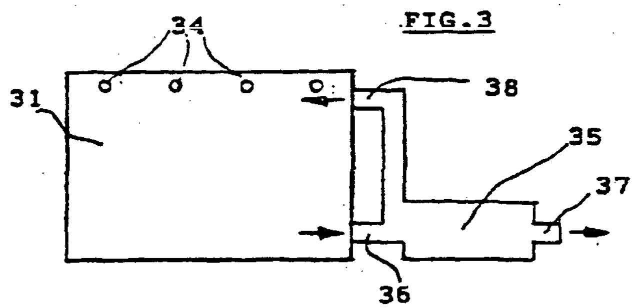

FIG.3

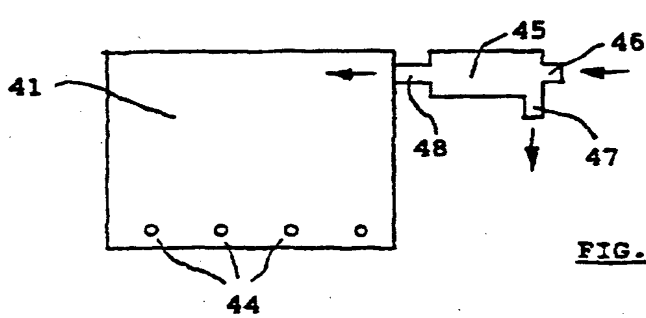

FIG.4

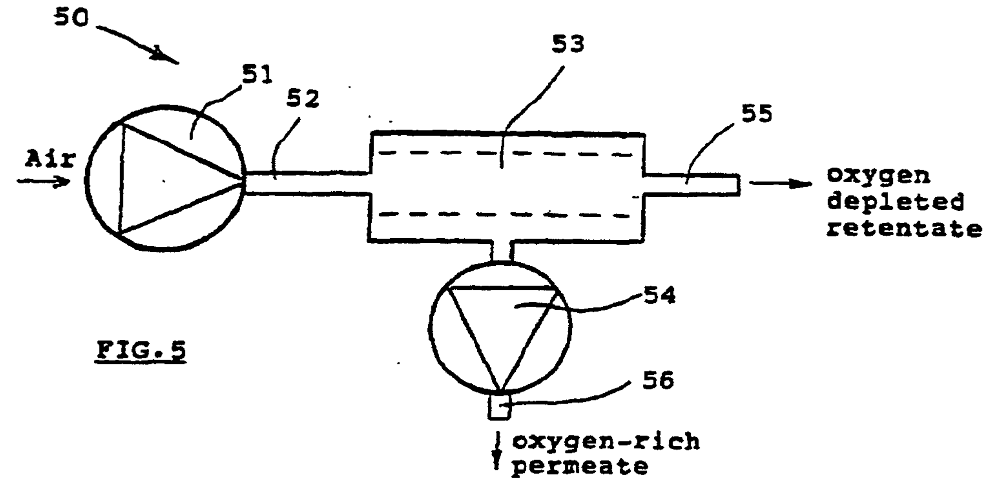

FIG.5

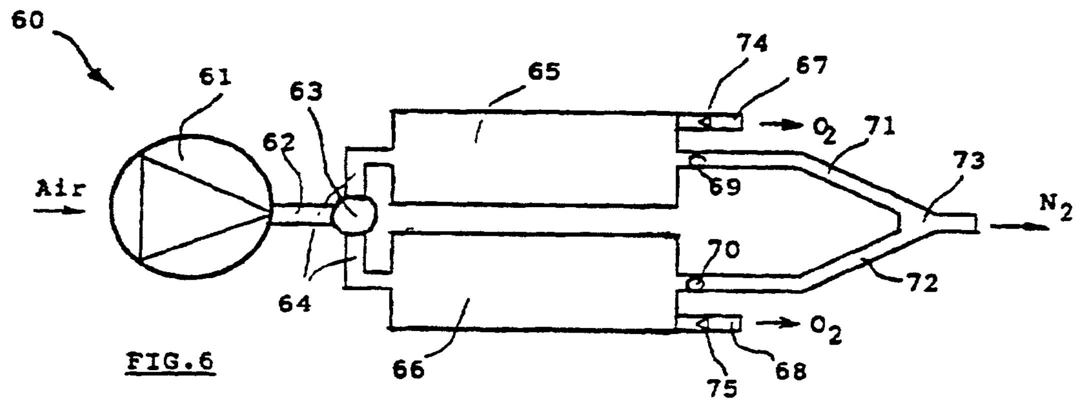

FIG.6

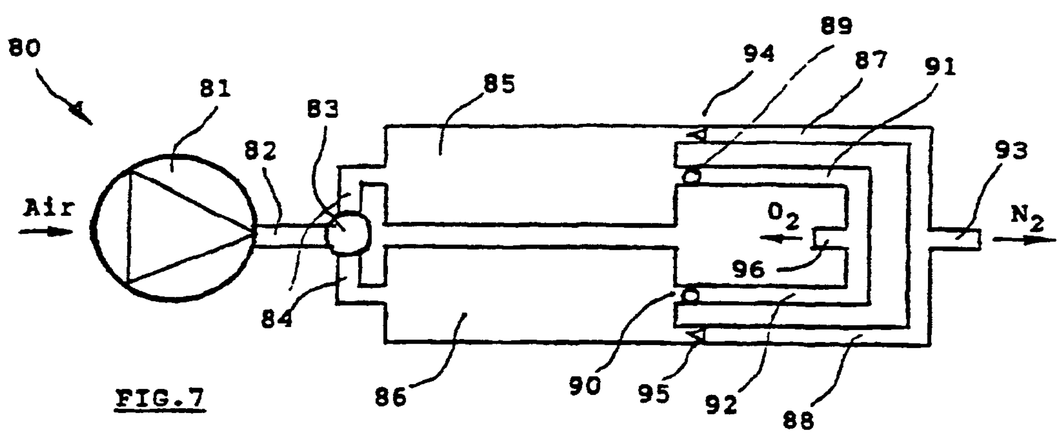

FIG.7